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# THE OCCURRENCE OF ARSENIC IN SOILS, PLANTS, FRUITS AND ANIMALS.

By WM. P. HEADDEN.

Read at the Meeting of the Society, June 4, 1910.

That arsenic may be present in the earth of graveyards and in arable soils has been considered as an established fact for, at least, the past seventy years. Orfila says that he found, in 1839, that the earth of a graveyard might contain arsenic in one place and be entirely free from it in another. (Orfila, German translation by Dr. G. Krupp, Vol. 1, p. 333.) From that time to the present, toxicologists have considered the possibility of its presence in the soil. They agree, however, that the arsenic is present as a lime or iron salt which is insoluble in water, even if it contains ammonia, as may be the case with the waters of a graveyard.

The probability of arsenic finding its way into the animal body by means of our foods is much stronger than its imbibition from the earth by a corpse, especially as the use of artificial manures and the spraying of plants as a protection against the ravages of insect pests has already become very general. Dragendorff, in his work entitled Die Gerichtlich-Chemische Ermittelung von Giften, p. 327, makes specific mention of the possibility of arsenic finding its way into the animal system by means of food plants growing in soils containing arsenic.

There is nothing new in these facts but their importance is growing with the continued application of these various arsenical preparations and of manures containing arsenic. Arsenic may get into our food even more directly, i. e., if commercial sulfuric acid is used in preparing any portion of it, glucose syrups, for instance.

The amounts of arsenic found in the soil have usually been considered is so small, mere traces, and so insoluble that but little weight has been attached to this occurrence from a chemico-legal standpoint. Otto, 5th Ed. p. 102, says: "that in his opinion, the danger of arsenic being imbibed from the soil by a corpse has been greatly over-estimated," but considers only the danger of imbibition by corpses. Mohr, Toxicologic, p. 54, says: "We know that it has come to pass in the detection of arsenic that some pretend to have found it in every earth and in every bone," and almost deprecates these tendencies on the part of investigators by stating "that such supersensitive reactions must lead to the gravest doubts." The author, of course, is referring to cases of arsenical poisoning.

At the time that most of these authors wrote, the use of commercial sulfuric acid in the manufacture of glucose, possibly to be used in the preparation of syrups, jellies or beer, or in the preparation of superphosphates to be put upon the soil, had not assumed the enormous proportions of the present time.

With the advent of the Colorado beetle we began to sprinkle our potato vines with Paris green. This must have been not later than the middle seventies, and since that time we have been diligent in combating the ravages of insects by means of arsenical preparations until we now not only sprinkle this poison on potato plants, cabbages, beets, etc., but drench our fruit and shade trees with such preparations in order that we may have fruit free from worms, or a good growth of foliage on our trees. This practice is common throughout the country, especially in sections where the above plants are grown. Up to the present time it has apparently been a choice between the destruction of some of our crops by insects or the use of these arsenicals. My object in this paper is to present some facts which have been established in the prosecution of a study of the effects of this practice on vegetation and the distribution of arsenic.

Dragendorff refers to the possibility of food plants taking up arsenic from the soil, and Holland, while making essentially the same statement, specifies "as turnips and potatoes."

Before passing to the question of the appropriation of arsenic by plants, I will record some observations relative to its presence in our soil. As stated before, the writers on toxicology, whose works I have been able to consult, consider that arsenic is seldom, if ever, present in more than traces. Hager, Untersuchungen, Vol. I. p. 645, expresses it, "That, in general, when any arsenic is present in the soil its quantity ranges within the limits of traces," and Wormley,—Micro-Chemistry of Poisons, p. 313, states "That the quantity of arsenic present in soils, according to various observers, never exceeds a mere trace . . . ." This can no longer be said to be true of many soils, especially of some of our cropped and orchard soils.

I have considered orchard soils mostly, but will also present the results obtained with virgin and unsprayed cultivated soils and some results following the spraying of potatoes. In a sample of orchard soil taken to a depth of five inches, I found arsenic corresponding to 30·6 parts of arsenic acid to each million parts of the soil, and in eight other samples taken to varying, but shallow depths, I found 25·5, 26·0, 36·8, 38·2, 40·0, 61·3, 128·8 and 138·0 parts arsenic acid per million of soil. I do not think that anyone can doubt but that the presence of such quantities of arsenic in the surface soil, must be attributed to the practice of spraying, especially as the presence of both lead and copper, arsenical salts of which are used in spraying, can be easily established.

I give in the following paragraphs a brief description of the methods used which will, I hope, be found full enough for the chemists and not tedious to others:

**Methods used.** The reagents were tested by blank experiments in which larger quantities were used than in the actual tests. The Marsh apparatus was sometimes, but not always, run for fifteen or twenty minutes before the prepared solution was introduced. This is an extra precaution which I have never found necessary. It has the advantage of adding weight to the time required for the solution to yield a visible mirror. If the prepared solution yields no mirror within fifteen minutes, the probabilities are that the preparation has been faulty or that arsenic is absent. The operator's knowledge of the facts and chemical judgment must determine the procedure to be followed; usually the test should be repeated.

The arsenic in these soils was determined by extracting the soil with concentrated nitric acid; the insoluble portion was washed on the filter with distilled water. The solution and wash water was concentrated to a convenient volume, then precipitated by addition of ammonia; there is usually a sufficient excess of ferric and calcic oxids to assure the precipitation of all of the arsenic acid. If there should not be a great excess of ferric oxid in the solution, ferric chlorid should be added. The precipitate was freed from nitrates by solution and reprecipitation or by solution in dilute sulfuric acid and subsequent evaporation. Both methods were used with good results.

With very marly soils and marls I first added distilled water, then $HNO_3$ until effervescence ceased, and heated the acid solution on an air bath to oxidize and arsenious to arsenic acid; 100 grams marl, and 75cc. $HNO_3$ conc. is usually a good proportion. After heating for some minutes a slight excess of $H_2SO_4$ conc. was added and the whole evaporated almost to dryness; too great an excess of $H_2SO_4$ should be avoided. The strongly acid mass is treated with distilled water and filtered at least four times and the filtrates evaporated down till there is not more than 50cc. of solution. If there is too great an excess of $H_2SO_4$ it is better to expel some of it by evaporation in a platinum or porcelain vessel, cool and dilute to about 50cc. before bringing it into the Marsh apparatus.

In the manipulation of wood, fruit, potatoes, oats, hay, etc., another method is advisable, i. e., char directly with $H_2SO_4$ conc.; 40 to 60cc. usually suffices. Heat over free flame till dry; the charred mass is pulverized and treated with $HNO_3$ conc.—50 to 100cc. will be required; it will usually be advisable to add this in two portions; no heat is applied till after the first violent action of the acid has abated, then heat till dry and pulverulent. If the carbon has caked, pulverize again, add 10 to 20 cc. $H_2SO_4$ and heat again. The latter operation may be omitted, but it will be found better to destroy all of the nitrated products by heating with $H_2SO_4$. I boil out the residual carbon four times, using from 150 to 200cc. of water each time. These wash waters should be kept strongly acid with sulfuric acid. The carbon is at last washed on the filter, using a pump. The united filtrates are to be concentrated to a convenient volume with the addition of $HNO_3$ conc. and $FeCl_3$ to assure the conversion of all the arsenic present into arsenic acid. Further, the $FeCl_3$ furnishes ferric oxid in very large excess over that necessary to carry down the arsenic acid on precipitation by ammonia. The precipitate is treated as given under the treatment of the soil.

The method used for the destruction of flesh was a conventional one, i. e., Gautier's method—treatment with $HNO_3$ conc. and the addition of $H_2SO_4$ after the volume of the solution had been somewhat reduced by evaporation.

The error attaching to these methods render low results and not high ones probable.

I have found some of our virgin prairie soils relatively rich in arsenic. These instances are so positive that we must consider the arsenic as occurring in the soil and that its presence is not due to accident, i. e., as derived from smelter fumes or any such source, but that it has accumulated in the soils in the same manner that many other salts, for instance, the marls, characteristic of our semi-arid regions have accumulated, namely by changes which have taken place in the soils themselves. I have examined virgin soils, all of them marly, from localities many miles apart, and have found them to contain arsenic, calculated as arsenic acid, as follows: 2·51, 2·76, 2·8, 3·8, 3·99, 4·2, 4·2, 4·7, and 5·0 parts per million of soil. These quantities cannot be considered as mere traces, but are quite small compared with the arsenic found to have accumulated in our orchard soils which show an average of 47·7 parts arsenic acid per million. These are surface soils, none of them having been taken to a greater depth than one foot.

I have tested both the orchard and the virgin soils for arsenic soluble in water, with the result that I have always found it present in the cultivated soil. I have, in six cases, weighed the arsenic recovered in this manner and obtained 0·68, 0·84, 1·04, 1·17, 1·265 and 1·342 parts arsenic acid per million parts of soil.

The virgin soils yield only slight traces of arsenic soluble in water. The orchard samples may show extreme results, but they are such as can be repeated from samples of soil taken from any of our orchards, especially if the samples be taken at or near the base of the trees.

The virgin soils examined were from widely separated localities; three of them were kindly furnished by the Kansas Experiment Station from Ft. Hays, Kansas. These samples were taken at points not less than one mile apart; one was collected in Prowers Co., Colo., about 2 miles west of the state line, others were collected on government lands in Delta and Mesa counties. The cultivated soils were gathered in Otero, Fremont, Montrose, Delta, and Mesa counties. The marls were obtained in Delta, Mesa and Larimer counties, Colo., and one was obtained through the courtesy of Prof. Thornber from Tucson, Arizona.

The statements of the authorities relative to the presence of mere traces of arsenic in soils is not true of the virgin soils examined, nor of orchard or other soils which have received sprayings with Paris green, arsenite of calcium, or any other arsenical preparation. Further the statement that the arsenic in the soil is present in an insoluble form does not apply to our cultivated soils which have been sprayed.

In the practice of spraying the assumption has been that the substances used are insoluble in water. This is by no means the case. Paris green, especially if a small amount of lime be added, yields arsenious acid quite freely to water, and the same is true of calcic arsenite which I found to be quite soluble in water. Lead arsenate, $Pb_3(As\ 0_4)_2$, is the most insoluble arsenical preparation used for spraying, but even this yields arsenic acid to distilled water, though the lead salt may have been persistently washed in preparation for the test. There is then no good reason why soils containing these materials should not yield arsenic when treated with water. The soil, waters, however, containing chlorids, sulfates and carbonate in solution are more efficient in taking the arsenic into solution than pure distilled water. Lead arsenate, for instance, yields arsenic acid readily to solution of sodic sulfate or chlorid. I may, before dismissing the subject of the solubility of lead arsenate, essentially $Pb_3(As\ 0_4)_2$, state that we found that about 0·3 per cent of the weight of the lead arsenate experimented with is soluble in distilled water. Two experiments were made and in each case the lead did not seem to go into solution at all. I made this observation in an experiment conducted throughout by myself and because of the apparent absence of lead I had Mr. Douglass, one of my assistants, make a parallel experiment with no knowledge of the results that I had obtained; his experiment confirmed mine.

I will not venture further in this line than to state the observed facts—that arsenic is present in our marly, virgin soils in quantities that exceed traces; that it is present in very greatly increased quantities in our orchard and cropped soils which have been sprayed, and that though our soils abound in carbonate of lime and contain considerable quantities of oxid of iron, there are weighable quantities of arsenic, from 0˙68 to 1˙345 parts per million, soluble in water.

Dragendorff and Holland mention the fact that food plants may take up arsenic from soils containing it, the latter has suggested the superphosphates, made with commercial sulfuric acid as the source of the arsenic, but the arsenic added in the form of superphosphates is insignificant compared with the quantities added as sprays.

The practice of spraying the potato plant to protect it against the attacks of the potato beetle has been in vogue longer than that of spraying apple and pear trees and the question whether the tubers contain arsenic or not and whether this arsenic may to any extent find its way into grains and grasses subsequently grown on this land are certainly germane. There is no doubt but that superphosphate of lime made with commercial sufuric acid may contain arsenic and that this arsenic will be present in a soluble form. The amount of arsenic present in crude sulfuric acid is, as a rule, very small and the amount applied to the land in this way is comparatively insignificant as will appear from the consideration that commercial sulfuric acid made from pyrites is described as containing a trace of arsenic. I have nowhere found any statement of the quantity, but given in fractions of one per cent, it would, in almost all cases, be very small. I recently tested a sample of superphosphate for arsenic and found that 5 grams would scarcely give a weighable quantity,—that would be, in this case, scarcely more than 0·005 of a milligram or 0·000075 of a grain. The sample was one obtained on the market. Again no very large amount of superphosphate is added to the soil, assuming that 1000 pounds of this fertilizer were applied per acre and that it contained 0·05 per cent of arsenious acid, the amount of the latter added would be 0.125 part per million of the surface foot of the soil. The above assumptions are gratuitously high —and yet the amount of arsenious acid added would amount to only one-half pound per acre. I have the record of a potato field, and it is not an exceptional one, to which 15 pounds of Paris green was applied in 1909. Assuming that this Paris green contained 50·0 per cent of arsenious acid, there was applied to the soil 7·5 pounds or as much white arsenic as would be applied in 15 applications of superphosphate under the above assumptions. There is no question but that soils which may have originally been entirely free from arsenic might show its presence after years of fertilization with superphosphate but the accumulation in this manner is extremely slow compared with its rate of increase in cases where spraying is practiced.

This arsenic is not only distributed throughout the soil but it is taken up by the vegetation. I tested the potatoes whose vines had been sprinkled with 15 pounds of Paris green during the season of 1909, using 800 grams of the tubers, and obtained a very satisfactory mirror. The tubers were first washed and then pared to prevent any arsenic getting into the sample as a mechanical impurity. The reagents had been tested and found to be free from arsenic. In another case, I obtained a sample of oats grown in 1909. The land had been planted to beets in 1908 and also in 1907. In 1906 it had been in potatoes and had received an application of six pounds of Paris green per acre. Three hundred grams of the oats gave a small but distinct mirror. I do not know whether there was any arsenic in this soil originally or whether it had ever received any other application of arsenic than in 1906, but this was the last application that it had received.

These questions lead directly to the further interesting one, namely, whether the arsenic present in our virgin soils may be taken up by vegetation, for instance by alfalfa, and in this way be further distributed.

We have seen that our virgin soils, as a fact, frequently contain arsenic. The amounts recovered in nine samples were 2·51, 2·76, 2·80, 3·80, 3·99, 4·20, 4·20, 4·70 and 5·00 parts of arsenic acid per million of soil, and I have examined other samples with similar results. The smallest amount recovered corresponds to over 10 pounds of arsenic acid per acre foot of soil, and the maximum to 20 pounds. These are certainly significant quantities.

In the first paragraph of this paper, I state that the fact of the occasional occurrence of arsenic in graveyards has been known for a long time, but that the toxicologists have considered it as existing in the soil in an insoluble form. If arsenic occurs in plants grown on soils containing it, the plants have either brought it into solution or it is more soluble than has been assumed. Whatever may be the facts regarding the power of plants to bring such substances into solution it is easily demonstrated that distilled water will dissolve small quantities of arsenic out of these soils. Ten virgin soils were treated with distilled water for periods varying from 36 to 48 hours and we obtained but one doubtful result, the other nine showed distinctly that arsenic had gone into solution.

After the results obtained in the examination of the potatoes and oats grown on ground that had been sprayed, it would seem to be only a question in regard to the rate at which the plants gather the arsenic from the soil whether it would be found in them or not. Alfalfa is cut as a rule three times during the season,—the first time in June, the second in August and the third in September. The growing season may be counted from the middle of April to the 20th of September. This would allow an average of seven weeks for the growing of a cutting of alfalfa. It is evident that we have no reason for anticipating the presence of more than a trace of arsenic, even on the supposition that the arsenic is perceptibly soluble in water, but 100 grams of alfalfa cut from a field which had been in alfalfa for 18 or 19 years and which, therefore, had in all probability never been sprayed, gave a distinct trace of arsenic. When we consider the short period of growth and the moderate amount of arsenic in the soil in this case, five parts of arsenic acid per million in the surface acre foot, or the equivalent of 20 pounds of this acid per acre, we are forced to attach more significance to these facts than they, at first glance, seem to deserve.

As this alfalfa is used very largely for the fattening of beeves and sheep, the question of the presence of arsenic in the flesh of these animals appeared of sufficient interest to justify the determination of the facts in the case. It would seem self-evident, in the light of our knowledge regarding the absorption of arsenic, especially by the liver, spleen and kidneys, that these organs, would contain arsenic in quantities sufficient to be detected.

This result appears almost certain when we consider that a steer, say of 1000 pounds weight, having an abundant supply of alfalfa hay at its disposal all the time, will eat, at least, thirty pounds per day. Assuming that the mirror obtained from 100 grams of hay was the smallest that I could weigh on the balances which I used, such an animal would consume 1·5 grains of arsenic acid daily. This is taken as the minimum—for the mirror obtained from 100 grams of alfalfa hay would weigh more than 0·005 milligram.

I was fortunately able to obtain a porter house steak and a kidney from an animal which had been fattened by a party whose land I had previously tested for arsenic, and which adjoins the land on which the sample of alfalfa hay just referred to was grown. By accident this party and I met in the meat market and he identified the beef on the block as of his fattening.

The steak was rather fat and I obtained only 410 grams of clean muscular tissue which gave, on being treated in the usual way, with concentrated nitric acid, sulfuric acid, etc., a medium mirror, which became visible in the tube of the Marsh-Berzelius apparatus in twelve minutes.

The kidney was removed from the leaf in my presence, so that I am sure that it had not been exposed to accidental contamination. No portion of the lining of the pelvis was taken, only the cortical tissue, of which I had 471 grams. The solution prepared from this gave a rather heavy mirror which began to appear in eight minutes after the introduction of the first portions of the solution. I would estimate the weight of this mirror at more than 0·1 of a milligram.

The presence of arsenic in virgin soils combined with its presence in the alfalfa suggests the question of its possible presence in the native vegetation growing in these virgin soils. The localities from which my samples were gathered supported no other available vegetation than the *atriplex confertifolia.* It was not feasible in this instance to remove the bark and use only the clean wood. The sample was, however, cleaned to remove as much dust and dirt as was possible. Seventy grams of the sample sufficed to give a faint mirror of arsenic. I have no hesitation in accepting this result as positive proof that the atriplex had taken the arsenic from the soil, which in this case contained arsenic equivalent to 4·2 parts of arsenic acid per million.

The statements of the first few paragraphs of this paper based upon the texts of experienced and accredited toxicologists, are evidently not applicable to our western soils even in their virgin condition, and not to any soils which have been sprayed. Again the assumption that the arsenic, when present in soils, is insoluble in water is not strictly true of our virgin soils and in a very much less degree of such as have been sprayed. I will recall in this connection, the fact that such soils yield arsenic to distilled water, not in traces, but in quantities ranging from 0·68 up to 1·345 parts of arsenic acid per million of soil.

Again many of our soils are underlaid by a marl. This too, has been subjected to examination and found to be richer in arsenic than the soil. The maximum quantity weighed corresponded to 15·33 parts arsenic acid per million. Other samples gave 3·8, 5·212 and 7·053 parts arsenic acid per million, while others gave heavy mirrors which were not weighed.

The suggestion of Dragendorff that arsenic may find its way into the animal system by means of plants growing on soils containing arsenic becomes a very cogent one in view of the facts here adduced.

There has, from time to time, been some discussion relative to the presence of arsenic in the human body. Some have claimed to have found it in bodies assumed to represent the normal condition; others have vigorously denied this to be the case, and have generally been considered as having established it as a fact that arsenic is not a normal constituent of the human body. But evidently if the cattle that furnish the beef of our markets be fed on alfalfa hay containing arsenic,—if the potatoes and the oat meal, and probably other grain-products that we eat, contain arsenic, it is difficult to see how our bodies can be free from it though it is not a normal constituent of them.

Some may infer that the statements of this paper pertain to a small section or sections of country and have no general significance. The statements pertaining to the virgin soils are based on the examination of samples as widely separated as Ft. Hays, Kansas and Grand Junction, Colorado. Those pertaining to sprayed soils on samples from western Colorado to eastern New York.

Whether there may be any danger of a corpse imbibing arsenic from the soils mentioned or not, there is no doubt about its passing into the fruit and other products obtaining their nourishment from such soils. The arsenic is not only taken up by the apple and pear trees, but it is retained in the pulp of the fruit that grows on them, and I know of no reason why this should not be the case with other fruits whether they be large or small ones. I have examined apples from

California, Colorado, Illinois, Michigan, Ohio, Pennsylvania, and New York, with the uniform result that they contain arsenic. Some of the samples were bought in the markets of different towns, some of them were gathered from the trees on which they grew. Some of the apples tested were grown on trees which had received four sprayings during the season, others were from trees which had received no spraying during the season. Some were grown on apparently healthy trees, others on sick ones. Of course, I know nothing of the history of the California fruit purchased in a Colorado town, or of apples purchased in a grocery store in Troy, New York. They were simply commercial apples and had probably been sprayed. They all showed the presence of arsenic, some much, others less. I weighed the arsenic recovered from three samples of apples, and one sample of pears. The apples gave 2·3, 0·52 and 0·68 parts arsenic acid per million of pared fruit; the pears gave 0·52 parts arsenic acid per million. I put myself and my friends to some trouble to obtain samples of commercial fruit from different states in order to obtain results representative of general facts and not of special conditions, such, for instance, as might obtain in a single county in Colorado.

It may be objected that this arsenic found in the fruit did not come from the soil but was absorbed directly from the spray applied to the fruit, or indeed that it may actually have been spray material driven into the calyx-tube of the fruit. The preparation of the sample guarded against such an error, for only perfect fruit was taken. This was thoroughly washed, pared, the calyx-tube pared away and the core take out, so that mechanical contamination of the sample by spray material was guarded against. I further considered that it is possible that spray material might gain entrance through the skin; to meet this difficulty, I obtained fruit from trees which, previous to the present year had been sprayed very regularly for the preceding 15 or 16 years, but had not been sprayed during the year 1909. These apples gave me a good mirror, not weighed because I did not collect all of the arsenic.

There is no lack of evidence that arsenic is taken up from the soil by the roots of the trees whether the spray material finds its way into the tissue of the leaf or other parts of the plant through stomata or lenticles or not; for instance, I cut off a limb of a Jonathan apple tree on the 8th of April and on the 12th of May I found the wound well coated with a deposit of dried juice. The tree had not been sprayed in the meantime, so I gathered this dried juice and tested it for arsenic by dissolving it in cold water and filtering to guard against the rather remote danger of obtaining arsenic from the soil dust that might have been blown into it. I had but 2·20 grams of this material, still it gave a very satisfactory mirror, for so small a quantity; again, I have examined the leaves of trees which had not been sprayed in 1909, though formerly sprayed annually from two to four times, and these contained arsenic. I do not think that any doubt can obtain but that the fruit of apple and pear trees sprayed with arsenical preparations contains arsenic, and that this is general without regard to the character of the soil, so long as it, the soil, contains arsenic, and most of the soils of commercial orchards now contain this substance, for we have been using it on apple trees for about 27 years.

I do not see any reason why the same facts do not hold for the peach, prune and other fruit grown between apple trees which are sprayed and the soil filled with arsenic; in the case of the peach we now spray the tree to protect it against the twig borer. I have, in fact, examined the wood of peach trees grown as fillers in an apple orchard and found the woody tissue rather rich in arsenic, though the trees themselves, according to the records which had been kept for a number of years, if not from the beginning of the orchard, had never been sprayed.

The next question that I have tried to answer is whether the arsenic is abundant enough in the fruit to be detected in the urine of persons eating freely of it. To this end, I purchased a box of Jonathan apples at a grocery store. I had them tested and they proved to contain arsenic, 0·68 parts arsenic acid per million of pared fruit. Three of us (two of my assistants and myself), ate of them and collected our urine. The apples were washed and pared to avoid eating any minute particles of arsenate of lead that might be adhering to them or lodged in the calyx-tube. The maximum quantity eaten was 7·7 pounds containing about 3/100 grain of white arsenic. The urine collected was in the first case three litres, which, after proper preparation yielded a strong mirror in the Marsh-Berzelius apparatus. The result in the second case was the same. In the third case, the urine was concentrated by evaporation and tested by the Reinsch method with satisfactory results. We are all persons in good health and have not taken arsenic in any other form for years so far as we can remember.

In conclusion, we have the following facts:

*First,*—Arsenic is widely distributed in our virgin soils, particularly in such as are marly, the amount ranging from 2·5 to 5·00 parts per million.

*Second,*—The marl underlying this soil contains more arsenic than the soil, the quantity present ranging from about 4 to 15 parts per million.

*Third,*—This arsenic is slightly soluble in water.

*Fourth,*—Alfalfa and the salt bush, atriplex confertifolia, growing on these soils contain arsenic.

*Fifth,*—Our orchard soils which have been sprayed for a number of years contain very much larger quantities of arsenic, from 10 to 28 times as much as the virgin soils.

*Sixth,*—The orchard soils which have been sprayed contain a weighable quantity of arsenic, which is soluble in water, this quantity varying from 0·68 to 1·345 parts per million of the soil.

*Seventh,*—This is a general fact, independent of the character of the soil, though the presence of the sulphate or chlorid of sodium in some soils may increase this solubility.

*Eighth,*—Oats, potatoes, apples and pears grown on such soils contain arsenic.

*Ninth,*—Arsenic is present in the flesh, kidneys and most probably in the other organs of animals fattended on alfalfa grown on soil containing this element.

*Tenth,*—The urine of persons who had partaken freely of the apples grown on sprayed trees, showed that the arsenic passed through the system as it was easily detected in the urine of three persons with whom the experiment was carried out.

The conclusion is evident that the human body may obtain arsenic from any of these foods, meats fattened on some alfalfa hays, sprayed potatoes, oats grown on ground that has been sprayed, or from pears and apples grown on sprayed trees.

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